TABLE 3.—*Illumination equivalent of a gram-calory per minute per square centimeter of radiation with the sun at different zenith distances*

Air mass Solar zenith distance	1.1 25°	1.5 47.3°	2.0 60.0°	2.5 67.6°	3.0 70.7°	3.5 73.6°	4.0 75.7°	4.5 77.4°	5.0 78.7°
Direct solar radiation	F. C. 7020	F. C. 6880	F. C. 6740	F. C. 6650	F. C. 6580	F. C. 6520	F. C. 6460	F. C. 6410	F. C. 6370
Total radiation on a horizontal surface	7000	6740	6470	6320	6260	6220	6200	6200	6200

Figure 4 is a copy of the record made by the pyrheliometer on July 11, 1924. The upper trace is a record of the total (direct solar + diffuse sky) radiation received on a horizontal surface. The lower curve is drawn through records of sky radiation only, obtained by shading the pyrheliometer from direct sunlight. Vertical rows of dots were made on the record sheet at 6 a. m. and 6 p. m., apparent time, or about 6:13 a. m. and p. m., 75th meridian time. They show that the register clock was faster than apparent time, and gaining.

In figure 5 are reproduced three record traces made at the Weather Bureau Observatory, University of Chicago, in October, 1923. October 23 was a cloudless day, with a moderate northeast wind from off Lake Michigan, about a mile distant, which blew away the city smoke. October 22 was also a cloudness day, but with a light wind from the northwest in the morning. The station records state that "Dense city smoke prevailed until 10:30 a. m. (10:51 apparent time), when it was swept away by the wind shifting to the northeast. Standing objects not visible much in excess of one-eighth of a mile." Between 10 a. m. and 11 a. m., when the depression in the record is greatest, the radiation intensity averaged 24 per cent as great as during the same hour on the 23d.

On October 26, the observer's notes read: "Dense city smoke during forenoon. Sky overcast with clouds. Light rain after 2:43 p. m."

As we would expect, comparisons of individual series of photometric readings with the pyrheliometric record show large departures from the mean results given in Table 3. Thus, from the photometric readings made at about 7:48, 8:31, 9:51, and 11:48 a. m., July 11, 1924, we obtain for the ratio

$$\frac{\text{Illumination intensity (F. C.)}}{\text{Radiation intensity (gr.-cal./min.cm.}^2\text{)}}$$

the values 6320, 5920, 6400, and 7460, respectively; and at 10:08 a. m., 12:09 p. m., and 1:58 p. m., July 18, 1924, the ratios 7850, 6580, and 7140, respectively. It is believed that these variations are to be attributed principally to inaccuracies in the photometric readings rather than to inaccuracies in the pyrheliometric record. The sky was somewhat clearer on July 18 than on July 11.

A comparison between the illumination and the radiation intensities of sky light made at Washington, D. C., in summer, indicate that it is relatively richer in luminous radiation than is direct sunlight, and especially with low sun. This is hardly what we would expect from a comparison, in Figure 1, of Curve VII, for sky light, and Curves II, III, IV, and V, for sunlight, with Curve VI. It must be remembered, however, that a summer sky in Washington has a much lower color temperature, and, in consequence, radiates relatively less of the ultra-violet than is indicated by Curve VII. Therefore, the ratios as found may be correct; but in comparisons of skylight intensity we must take into account a large probable error in both the pyrheliometric and the photometer readings.

When dense clouds cover the sky so that the radiation intensity is perhaps even less than that from a clear sky the ratio of illumination intensity to radiation intensity is likewise abnormally high. The mean of 13 series of comparisons between illumination and radiation intensities with a completely overcast sky gives for the above ratio the value 7440.

Curve VII in Figure 1 indicates that for clear sky the ratio

$$\frac{\text{Illumination intensity}}{\text{Radiation intensity}}$$

should be lower than for direct solar radiation. Priest's color temperatures of sky light, already referred to, give a like indication, although with cloudy skies the difference is small.

CONCLUSIONS

With cloudless skies the illumination equivalents of Table 3 when applied to radiation intensities should give daylight intensities with an accuracy comparable to that of ordinary photometric readings. The factor 6700 will, on an average, give the daylight intensity within ±5 per cent, giving too low intensities near noon in summer and too high intensities when the sun is near the horizon.

With the sky covered with clouds the factor averages higher, probably not far from 7,000.

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APPLICATION OF SCHUSTER'S PERIODOGRAM TO LONG RAINFALL RECORDS, BEGINNING 1748

By DINSMORE ALTER

(University of Kansas, Nov., 1924)

The present paper is an extension of work on rainfall periodicities carried on during the past four years(**1**). In the previous papers a single short periodicity was investigated. In the present paper the investigation is carried to longer periods to which a much more general method of analysis must be applied.

Of the various methods that have been proposed in the search for hidden periodicities, that formulated by Schuster (**2**) and used by him in a search for periods in the Greenwich magnetic data, seems the most practical for application to this problem.

Schuster's method consists, first, of passing sine curves, of arbitrarily selected periods, through the data in such manner as best to represent them by each. These periods must be so closely chosen that there shall be no intermediate ones untried that can have a large final disagreement in phase from the next neighboring one chosen for examination. The second part of the method consists of plotting the intensities of these curves as ordinates of another curve whose abscissae are the periods so chosen. This last curve he calls the periodogram.

The method of obtaining these sine curves is as follows: Suppose a period to be tried of length equal to n times the time interval α between successive observations. The first n data values are then written as a row, each heading a column. The next n values then form the second row of these n columns, etc, until all p observations have been used or, as is often done, until there are not enough data left to form another complete row. In the first case the average value of each column is taken, in the second the sum may be used instead. The first case has a slight theoretical disadvantage in that columns of slightly different weight are considered as being of equal weight. Schuster used the second alternative, although it involves the neglect of considerable data when long periods are being investigated. In this paper the column averages are used.

Let any one of the sums of the n columns be ϕ_m. Schuster defines

$$A = \Sigma \phi_m \cos \frac{2\pi_m}{t} \quad B = \Sigma \phi_m \sin \frac{2\pi_m}{t}$$

$$S = (A^2 + B^2) \frac{\alpha}{p}$$

If we define averages instead of sums, as ϕ_m we must then define

$$I = \frac{A^2 + B^2}{\eta^2 \alpha^2}$$

since $\dot{S}$ determined by the former equation would increase as the square of the period examined.

He defines as h the ratio between I of any period and the mean value of I. The probability, then, of obtaining a given value of h, or larger, by accident is $1/\epsilon^h$. About one computed value of h out of a thousand should be as large as seven by mere accident, and about one out of a million as large as 14.

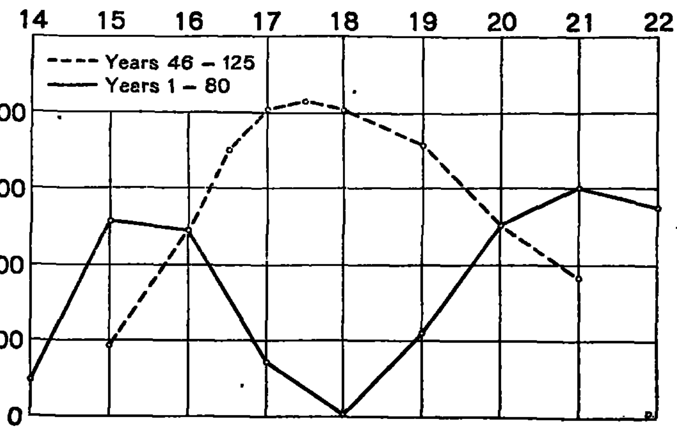

FIG. 1.—Periodogram from years 1-80 and 46-125 of fictitious data

Although Schuster has brought out analytically the limitations of the periodogram in resolving power, these are larger than is often recognized and it may be well to show them by a numerical example. For this purpose values of fictitious data have been computed from two sine curves, at phase zero, together at the year 1, of equal amplitudes and of periods 16 and 20 years—a case much simpler than will be met in actual investigations and, therefore, giving a smaller range of uncertainty to deductions from the periodogram. The irregular curve obtained by adding these components repeats itself every 80 years. Periodograms have been computed from two 80-year intervals; i. e., from years 1–80 and 46–125. The data are given in Table 1 and the periodograms in Table 2 and Figure 1. Exactly the same shape of curve has given each of these periodograms. The data have merely begun in one place for one and in another place for the other. Since the ordinates of these periodograms for periods below 15 and above 22 are very small, rapidly approaching zero, the values of h at the peaks are very large and would, on our criterion of probabilities, indicate true periods. Yet one periodogram tells us that there is but one period of about 17½ years, the other that there are two, of 15½ and 21 years, these despite the fact that in this case we know that there are two of 16 and of 20 years. *However, the periodogram has value even in these cases for it tells us that there are one or more true periodicities in this general region, even though it can not locate them accurately.* Evidently no period of length $n\alpha$ making p/n cycles in the data can be located more certainly than within a range r such that $r > \frac{n^2 \alpha}{p-n}$. How much greater r must be than this value will depend upon the complexity of the data and the importance of accidental or other nonperiodic factors. For example, even if the sun-spot data were the combination of two fairly short constant periodicities, without other factors entering, the 173 years' data available would not locate the true length of the 11-year period within about two-thirds of a year. No matter how sharply the periodogram seems to locate a period, we must at all times allow this range, a greater uncertainty than some investigators seem to have realized.

The first part of this investigation consisted of a search for and combination of the longest rainfall records available in various parts of the world. As in the preceding papers, an attempt was made to use all long records that are from stations where the rainfall is either purely marine or purely continental and to avoid such places as the central part of the United States, where it is mixed, with no great preponderance of the one type over the other. Before combining different stations each year's data have been reduced to the percentage of normal which fell in that year, in order that the omission of years from some one station may not give a record lacking too much in homogeneity to be useful. Such lack of data is an unavoidable defect in the compilations of data by the weather bureaus of the United States and of other countries. In the case of monthly data there is the additional necessity of eliminating the seasonal variation. Usable records were found in northern Europe, eastern United States, California and Oregon, and in India. From the Indian data that of the Punjab, which is almost purely continental, was chosen. These records form Tables 3–6 and Figures 2–5.

In northern Europe it has been possible to compile a record of 173 years, during the great majority of which time three or more scattered stations are available. It is recognized that the weights of the early records are less than those of the later ones both because of the fewer stations available and also because, presumably, more care has been exercised recently. However, when one considers the question of adjusting weights he sees that any arbitrary scheme is open to objections. It has, therefore, seemed best here to make a solution considering all years as of equal weight. The periodogram from these data should locate fairly accurately periods of less than 10 to 15 years and tell us something about longer periods shorter than 40 years.

In the eastern United States there are available 17 station records, extending back at least to 1840, which have been sent to me by Professor Talman, of the United States Weather Bureau. I have not found any long New England records. These, reduced to percentages of normal, are given as Table 4 and as Figure 3, with their mean in the last column of the table. The mean forms a very valuable record of 103 years, second in weight only to that of northern Europe.

Mr. Beals and Mr. Wells, State section directors of California and of Oregon, respectively, have sent me eight long records, of which the percentages of normal form Table 5 and Figure 4. These give a 73-year record from which to form a periodogram.

In the Punjab a 56-year record, given as Table 6 and Figure 5, has been used.

Although not used in this paper and, therefore, omitted from the tables, the author has the monthly values of rainfall for each station used. Some of these can be found in the tables of the earlier paper mentioned above.

This search falls naturally into four parts, of which this paper presents the first:

(*a*) *Periodicities greater than eight years.*—For such periods yearly values of data are sufficient and the approximate and rather rapid method of calculation wherein a value is averaged or repeated in order to obtain non-integral periods is entirely satisfactory.

(*b*) *Periodicities between approximately four and eight years.*—Yearly values of data are still satisfactory, but in forming the tables for the computation of I the approximation involved in repeating or averaging a year can not be used. The tabulation of data in a column assumes that all the values are in the same phase. There will, however, when the device described above is used, often be half a phase departure from the proper place. If eight places are computed for the cycle, data will sometimes be displaced as much as 22.5°. This begins to count and for such periods it is necessary to compute accurately the phase of each datum value. This increases the work very much.

(*c*) *Periodicities between two and four years.*—At about four years the change in phase during a year makes it necessary to use data given at more frequent intervals. For this range quarterly values will suffice.

(*d*) *Periodicities between one and two years.*—Monthly values of data should be used.

The periodogram of northern Europe has, of course, a much greater weight than that from any other region. Short periods can be determined with greater accuracy, while longer periods can be determined than is the case with the shorter records. Three features are seen to stand out in this periodogram, which is shown as Table 7 and Figure 6. First in importance is the very low intensity between 10½ and 14 years; second is the very high intensity from 15 to 16 years; and third, the moderately high intensity near 10 years. The peak near 15 years with $h = 5.83$ is high enough to suggest that even without corroboration from other sections we may begin to consider the possibility of its existence as due to other than fortuitous causes. If it be real, its true length may, as

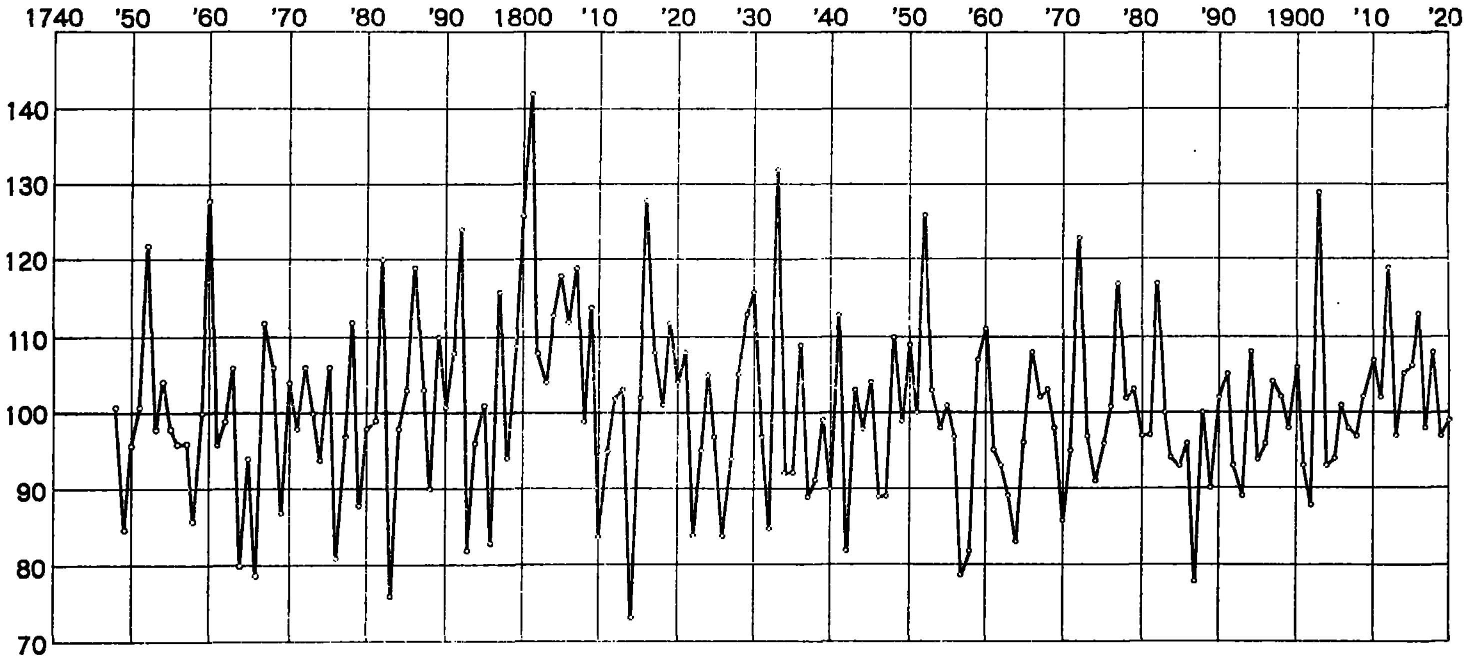

Fig. 2.—Rainfall of northern Europe

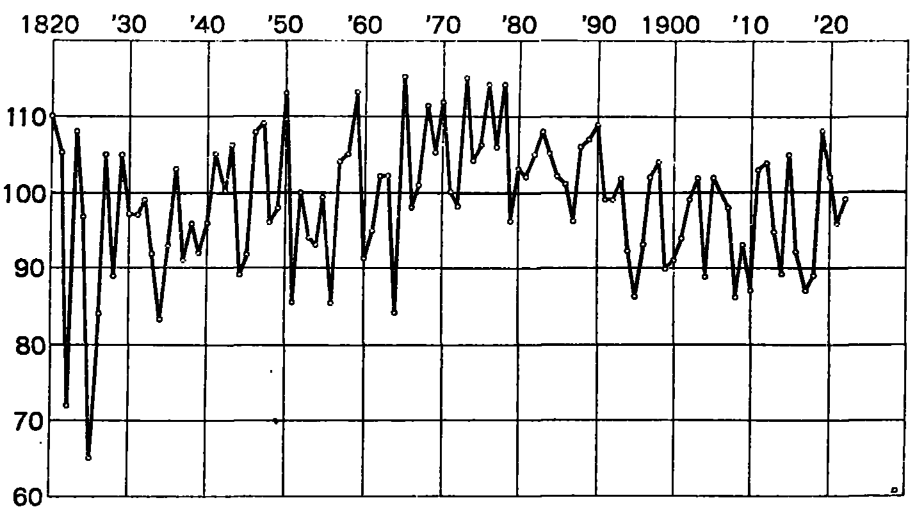

Fig. 3.—Rainfall of eastern United States

seen above, due to the limitation of the method, be anywhere between 14 and 18 years.

The periodogram of the eastern United States, shown as Table 8 and Figure 7, stands next in weight. Here

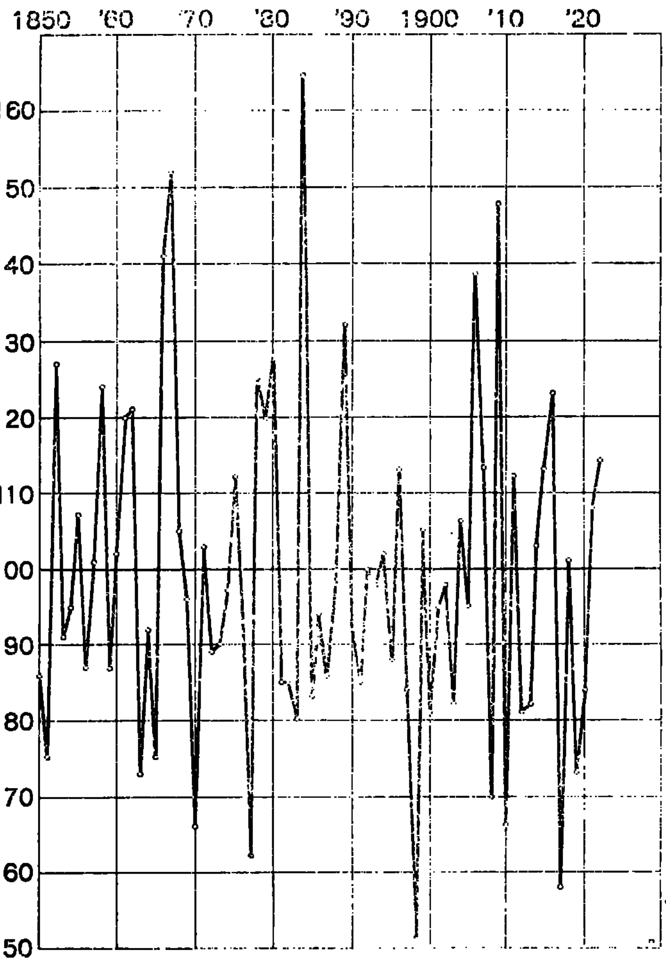

FIG. 4.—Rainfall of California and Oregon

again, we find entirely negative evidence concerning the 11-year period. The period of strongest intensity is found to be in very close agreement with that of second intensity for northern Europe. The second peak falls

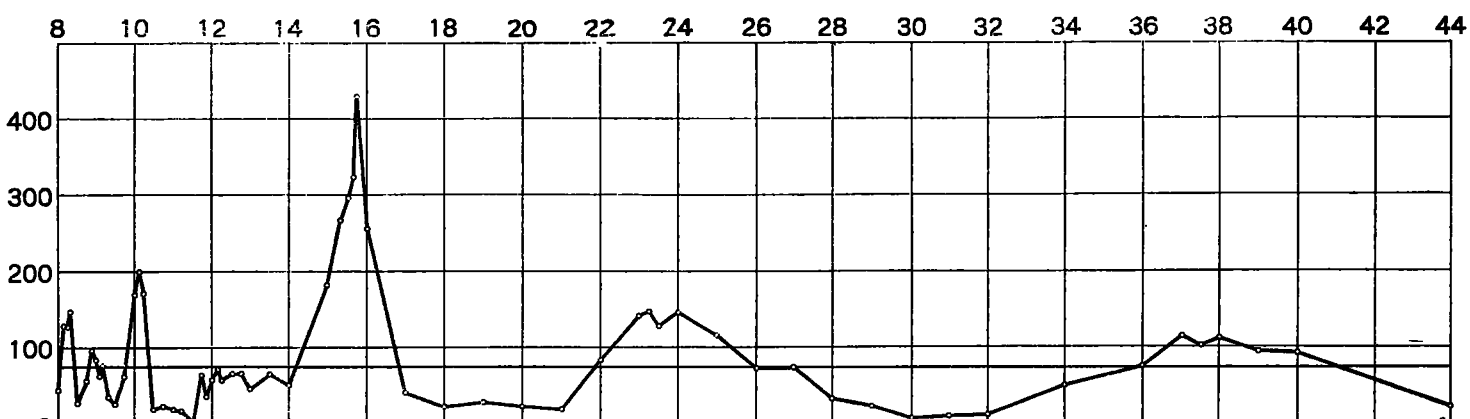

FIG. 6.—Rainfall periodogram for northern Europe. 1748–1920

at 14½ years with a range of fully two years in uncertainty, overlapping the primary peak of the northern European data.

The periodogram of next weight is that from the 73-years' data of the Pacific coast. This is shown as Table 9 and Figure 8. A third time we find that the 11-year period fails to appear, although the intensity rises above normal very soon thereafter. From 9 to 10 years the

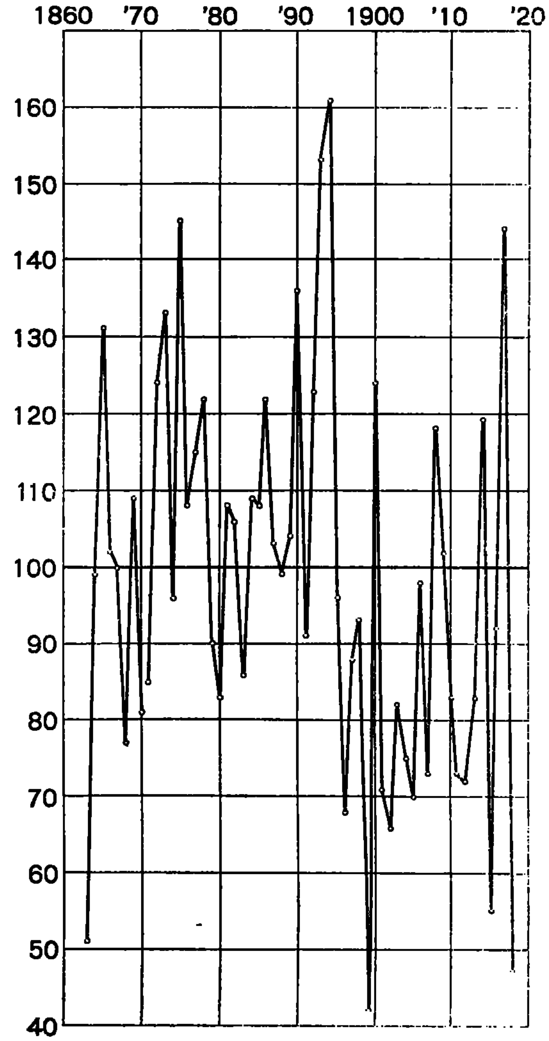

FIG. 5.—Rainfall of the Punjab, India

intensity is large, h reaching 4.47 for 9⅓ years. From 11½ to 15 years the intensity is continually above normal, possibly suggesting a blend of two periods as in Figure 2. It also rises very slightly above normal once more at 15⅜ years.

The data of least weight are those from the Punjab, shown as Table 10 and Figure 9, where only 56 years are available. This periodogram agrees very closely with the much longer record from northern Europe, except that it is impossible from such a short record to obtain large values of h. The 11-year period is entirely absent.

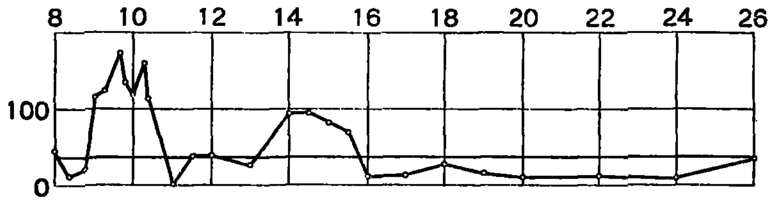

FIG. 7.—Rainfall periodogram for eastern United States, 1820-1922

The highest intensities are found in the regions near 10 and between 14 and 17 years.

These results from widely separated parts of the world seem to show definitely that a simple 11-year period

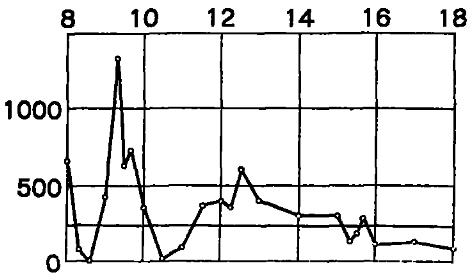

FIG. 8.—Rainfall periodogram for California and Oregon, 1850-1922

does not exist. However, some such period practically has been proved by Douglass (3). The conclusion, then, must be that Douglass's period is either a complex mean from longer and shorter periodicities or else a variable cycle.[1]

Nothing more is definitely shown here. It is probable that one or more periods exist in the neighborhood of 10 years. The same is true of the region between 13 and 16 years. If they do, whether they be exact periods or variable cycles can not be shown here. It may be possible to speak with more definiteness after the completion of the second division of the problem. On the otherhand, it may require many more data to give full assurance as to which is the case. Certainly the chance of knowing definitely about the shorter periods will be much greater than it can be for these longer ones.

My thanks are due to the research committee of the University of Kansas for a grant under which part of the computing was done.

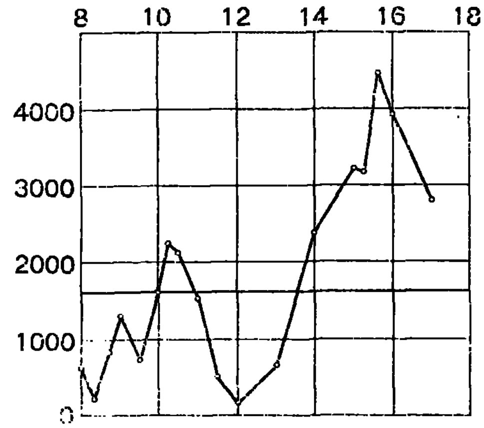

FIG. 9.—Rainfall periodogram for the Punjab, India, 1863-1918

[1] The point may well be emphasized that experience has shown it to be much more difficult to discern periodicities on the basis of precipitation data than on the basis of temperature data.

That the 11-year cycle is variable, and systematically so, is a principal thesis of a paper by H. W. Clough, of the United States Weather Bureau, entitled: "A systematically varying period with an average length of 28 months in weather and solar phenomena." See MO. WEATHER REV., September, 1924. Reprints of this paper are available.

Of the greatest significance also, in this connection, is the paper by A. A. Michelson, "Determination of periodicities by the harmonic analyzer with an application to the sun-spot cycle," in Astrophys. Jour., 38, 1913, pp. 268-274. On p. 273: "It will probably be found that even the 11-year period is in fact not constant, but is subject to secular change; * * *."—B. M. V.

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TABLE 1.—*Fictitious data, sum of two sine curves of amplitude 10 and periods of 16 and 20 years*

Year	Value	Year	Value
1 and 81	0.0	41 and 121	0.0
2 82	+6.9	42 122	−0.7
3 83	+13.0	43 123	−1.2
4 84	+17.3	44 124	−1.1
5 85	+19.5	45 125	−0.5
6 86	+19.2	46 126	+0.8
7 87	+16.6	47 127	+2.4
8 88	+11.9	48 128	+4.3
9 89	+5.9	49 129	+5.9
10 90	−0.7	50 130	+6.9
11 91	−7.1	51 131	+7.1
12 92	−12.3	52 132	+6.1
13 93	−15.9	53 133	+4.1
14 94	−17.3	54 134	+1.1
15 95	−16.6	55 135	−2.4
16 96	−13.8	56 136	−6.2
17 97	−9.5	57 137	−9.5
18 98	−4.3	58 138	−11.9
19 99	+1.2	59 139	−13.0
20 100	+6.1	60 140	−12.3
21 101	+10.0	61 141	−10.0
22 102	+12.3	62 142	−6.1
23 103	+13.0	63 143	−1.2
24 104	+11.9	64 144	+4.3
25 105	+9.5	65 145	+9.5
26 106	+6.2	66 146	+13.8
27 107	+2.4	67 147	+16.6
28 108	−1.1	68 148	+17.3
29 109	−4.1	69 149	+15.9
30 110	−6.1	70 150	+12.3
31 111	−7.1	71 151	+7.1
32 112	−6.9	72 152	+0.7
33 113	−5.9	73 153	−5.9
34 114	−4.3	74 154	−11.9
35 115	−2.4	75 155	−16.6
36 116	−0.8	76 156	−19.2
37 117	+0.5	77 157	−19.5
38 118	+1.1	78 158	−17.3
39 119	+1.2	79 159	−13.0
40 120	+0.7	80 160	−6.9

TABLE 2.—*Fictitious data of periods 16 and 20 years*

PERIODOGRAM FROM YEARS 1-80

Period in years	Intensity	A	B
14	479	−235	−197
15	2542	−652	+384
16	2455	0	+792
17	737	+367	+280
18	14	−67	+12
19	1071	+385	+489
20	2520	0	+1004
21	3018	+641	+959
22	2740	+1043	+485

PERIODOGRAM FROM YEARS 46-125

Period in years	Intensity	A	B
15	921	−372	−251
16	2480	−736	+304
16½	3500	−571	−828
17	4030	+389	+1005
17½	4157	−172	+1083
18	4040	+397	+1072
19	3590	+970	+593
20	2520	+1004	0
21	1810	+768	−456

TABLE 3.[1]—*Percentages of rainfall in northern Europe*

[See Table 11]

Year	Lund [2]	Abo [3]	Montdidier	Copenhagen [4]	Chilgrove	Utrecht	London	Haverford west	Glengyle	Belfast	4 stations in Norway	Mean
1748	(101)	------	------	------	------	------	------	------	------	------	------	101
1749	85	------	------	------	------	------	------	------	------	------	------	85
1750	91	100	------	------	------	------	------	------	------	------	------	96
1751	------	101	------	------	------	------	------	------	------	------	------	101
1752	------	122	------	------	------	------	------	------	------	------	------	218
1753	96	101	------	------	------	------	------	------	------	------	------	92
1754	89	119	------	------	------	------	------	------	------	------	------	104
1755	71	124	------	------	------	------	------	------	------	------	------	98
1756	75	117	------	------	------	------	------	------	------	------	------	96
1757	93	99	------	------	------	------	------	------	------	------	------	96
1758	81	92	------	------	------	------	------	------	------	------	------	86
1759	77	122	------	------	------	------	------	------	------	------	------	100
1760	119	138	------	------	------	------	------	------	------	------	------	128
1761	107	84	------	------	------	------	------	------	------	------	------	96
1762	107	91	------	------	------	------	------	------	------	------	------	99
1763	103	108	------	------	------	------	------	------	------	------	------	106
1764	80	------	------	------	------	------	------	------	------	------	------	80
1765	93	94	------	------	------	------	------	------	------	------	------	94
1766	82	76	------	------	------	------	------	------	------	------	------	79
1767	116	107	------	------	------	------	------	------	------	------	------	112
1768	105	108	------	------	------	------	------	------	------	------	------	106
1769	100	74	------	------	------	------	------	------	------	------	------	87
1770	110	97	------	------	------	------	------	------	------	------	------	104
1771	104	92	------	------	------	------	------	------	------	------	------	98
1772	117	96	------	------	------	------	------	------	------	------	------	106
1773	99	101	------	------	------	------	------	------	------	------	------	100
1774	111	76	------	------	------	------	------	------	------	------	------	94
1775	114	98	------	------	------	------	------	------	------	------	------	106
1776	89	73	------	------	------	------	------	------	------	------	------	81
1777	97	97	------	------	------	------	------	------	------	------	------	97
1778	101	123	------	------	------	------	------	------	------	------	------	112
1779	103	74	------	------	------	------	------	------	------	------	------	88
1780	103	93	------	------	------	------	------	------	------	------	------	98
1781	108	90	------	------	------	------	------	------	------	------	------	99
1782	131	109	------	------	------	------	------	------	------	------	------	120
1783	85	66	------	------	------	------	------	------	------	------	------	76
1784	97	101	96	------	------	------	------	------	------	------	------	98
1785	119	95	96	------	------	------	------	------	------	------	------	103
1786	131	115	110	------	------	------	------	------	------	------	------	119
1787	100	95	113	------	------	------	------	------	------	------	------	103
1788	94	83	92	------	------	------	------	------	------	------	------	90
1789	110	99	120	------	------	------	------	------	------	------	------	110
1790	113	94	96	------	------	------	------	------	------	------	------	101
1791	93	112	104	------	------	------	------	------	------	------	------	108
1792	130	126	116	------	------	------	------	------	------	------	------	124
1793	85	90	72	------	------	------	------	------	------	------	------	82
1794	91	114	83	------	------	------	------	------	------	------	------	96
1795	101	113	90	------	------	------	------	------	------	------	------	101
1796	98	70	81	------	------	------	------	------	------	------	------	83
1797	127	139	82	------	------	------	------	------	------	------	------	116
1798	122	88	71	------	------	------	------	------	------	------	------	94
1799	116	------	102	------	------	------	------	------	------	------	------	109
1800	134	------	117	------	------	------	------	------	------	------	------	126
1801	147	------	138	------	------	------	------	------	------	------	------	142
1802	122	------	94	------	------	------	------	------	------	------	------	108
1803	116	81	115	------	------	------	------	------	------	------	------	104
1804	(115)	101	124	------	------	------	------	------	------	------	------	113
1805	(128)	104	121	------	------	------	------	------	------	------	------	118
1806	------	103	120	------	------	------	------	------	------	------	------	112
1807	121	114	123	------	------	------	------	------	------	------	------	119
1808	119	88	90	------	------	------	------	------	------	------	------	99
1809	127	95	120	------	------	------	------	------	------	------	------	114
1810	78	74	99	------	------	------	------	------	------	------	------	84
1811	96	71	117	------	------	------	------	------	------	------	------	95
1812	78	98	131	------	------	------	------	------	------	------	------	102
1813	95	101	113	------	------	------	------	------	------	------	------	103
1814	61	74	85	------	------	------	------	------	------	------	------	73
1815	108	87	112	------	------	------	------	------	------	------	------	102
1816	109	128	146	------	------	------	------	------	------	------	------	128
1817	100	103	120	------	------	------	------	------	------	------	------	108
1818	103	87	113	------	------	------	------	------	------	------	------	101
1819	98	115	123	------	------	------	------	------	------	------	------	112
1820	103	100	110	------	------	------	------	------	------	------	------	104
1821	(111)	116	115	89	------	------	------	------	------	------	------	108
1822	87	65	98	84	------	------	------	------	------	------	------	84
1823	(97)	81	90	113	------	------	------	------	------	------	------	95
1824	106	89	106	118	------	------	------	------	------	------	------	105
1825	98	86	74	131	------	------	------	------	------	------	------	97
1826	64	68	85	88	------	------	------	------	------	------	------	84
1827	83	76	100	117	------	------	------	------	------	------	------	94
1828	101	92	110	118	------	------	------	------	------	------	------	105
1829	110	114	111	118	------	------	------	------	------	------	------	113
1830	(120)	117	98	127	------	------	------	------	------	------	------	116
1831	(117)	69	100	101	------	------	------	------	------	------	------	97
1832	(98)	90	80	71	------	------	------	------	------	------	------	85
1833	(120)	208	68	131	------	------	------	------	------	------	------	132
1834	98	96	80	90	96	------	------	------	------	------	------	92
1835	84	------	105	88	90	------	------	------	------	------	------	92
1836	93	78	118	119	119	------	------	------	------	------	------	109
1837	86	------	111	81	79	------	------	------	------	------	------	89
1838	84	------	99	92	89	------	------	------	------	------	------	91

[1] For data on lengths of periods, sources, etc., used in Tables 3, 4, and 5, see Table 11, following.

[2] From 1861–1910 mean value from Swedish towns is used.

[3] Beginning with 1803 Warsaw is substituted.

[4] Beginning with 1861 the mean of Danish towns is substituted.

TABLE 3.—*Percentages of rainfall in northern Europe*—Continued

Year	Lund	Abo	Montdidier	Copenhagen	Chilgrove	Utrecht	London	Haverford west	Glengyle	Belfast	4 stations in Norway	Mean
1839	77	-----	120	82	118	-----	-----	-----	-----	-----	-----	99
1840	91	-----	99	88	84	-----	-----	-----	-----	-----	-----	90
1841	140	71	99	127	127	-----	-----	-----	-----	-----	-----	113
1842	(78)	79	86	70	87	-----	-----	-----	-----	-----	-----	82
1843	95	91	107	121	101	-----	-----	-----	-----	-----	-----	103
1844	77	121	94	115	82	-----	-----	-----	-----	-----	-----	98
1845	113	89	104	123	90	-----	-----	-----	-----	-----	-----	104
1846	81	71	98	92	101	-----	-----	-----	-----	-----	-----	89
1847	73	98	114	86	76	-----	-----	-----	-----	-----	-----	89
1848	118	94	98	108	131	-----	-----	-----	-----	-----	-----	110
1849	99	107	95	106	96	93	-----	-----	-----	-----	-----	99
1850	85	154	106	102	94	114	-----	-----	-----	-----	-----	109
1851	92	149	82	102	76	96	-----	-----	-----	-----	-----	100
1852	146	84	122	119	148	135	-----	-----	-----	-----	-----	126
1853	75	136	100	86	111	108	-----	-----	-----	-----	-----	103
1854	90	127	111	98	64	96	-----	-----	-----	-----	-----	98
1855	96	147	87	90	84	100	-----	-----	-----	-----	-----	101
1856	81	94	104	102	96	106	-----	-----	-----	-----	-----	97
1857	70	101	79	65	91	67	-----	-----	-----	-----	-----	79
1858	68	121	79	71	76	80	-----	-----	-----	-----	-----	82
1859	113	129	100	107	100	95	-----	-----	-----	-----	-----	107
1860	121	106	104	102	122	98	126	119	103	111	-----	111
1861	94	90	76	103	84	92	87	108	122	98	-----	95
1862	99	67	79	99	94	76	108	80	114	113	-----	93
1863	94	77	63	98	89	71	84	94	115	107	-----	89
864	88	107	75	91	72	71	66	83	88	85	-----	83
1865	76	119	97	70	112	97	115	106	79	93	-----	96
1866	116	81	97	122	107	102	124	114	110	103	-----	108
1867	113	97	93	117	86	96	103	116	108	95	96	102
1868	.102	130	88	106	105	74	91	117	129	91	104	103
1869	97	109	83	93	97	113	99	114	90	94	83	98
1870	99	113	82	81	80	94	83	83	77	87	70	86
1871	85	119	100	84	97	96	98	97	98	92	76	95
1872	131	103	109	124	126	112	132	145	139	129	106	123
1873	109	101	87	105	91	92	89	95	104	90	102	97
1874	81	78	80	90	85	90	74	106	116	101	101	91
1875	78	99	89	90	103	110	111	122	99	93	67	96
1876	106	101	107	100	103	92	102	111	102	116	72	101
1877	108	86	121	119	131	112	110	134	140	122	106	117
1878	102	96	124	106	97	103	133	113	89	84	77	102
1879	97	101	110	102	108	98	132	103	95	97	88	103
1880	105	93	102	112	109	95	118	85	75	83	89	97
1881	109	75	100	90	99	108	109	94	87	111	90	97
1882	116	113	125	118	104	133	106	132	114	114	115	117
1883	102	-----	110	93	96	89	95	105	110	98	103	100
1884	100	-----	93	99	77	82	80	91	117	96	100	94
1885	41	-----	102	93	98	96	104	105	492	86	115	93
1886	34	-----	104	87	111	88	106	120	88	107	114	96
1887	84	-----	63	80	74	69	75	73	73	68	119	78
1888	97	-----	94	108	103	97	109	98	97	95	107	100*
1889	91	-----	92	84	87	114	93	77	83	90	87	90
1890	144	-----	99	97	85	117	83	89	104	94	109	102
1891	100	-----	-----	110	121	92	110	106	103	92	113	105
1892	93	-----	-----	92	81	110	88	78	98	90	109	93
1893	102	-----	-----	94	79	98	77	74	100	75	100	89
1894	109	-----	-----	100	126	128	109	104	111	91	98	108
1895	107	-----	-----	99	103	100	84	81	81	96	96	94
1896	108	-----	-----	92	105	99	92	85	83	95	106	96
1897	110	-----	-----	106	109	97	89	106	105	103	109	104
1898	128	-----	-----	120	83	102	69	88	122	88	119	102
1899	107	-----	-----	92	87	97	88	88	116	101	102	98
1900	112	-----	-----	112	113	96	91	104	113	117	100	106
1901	84	-----	-----	95	90	110	87	95	83	93	102	93
1902	91	-----	-----	91	99	92	81	84	72	88	98	88
1903	113	-----	-----	115	145	132	149	118	141	123	125	129
1904	105	-----	-----	96	107	78	81	89	97	92	96	93
1905	89	-----	-----	102	89	110	90	83	84	92	108	94
1906	103	-----	-----	98	114	94	95	105	89	104	111	101
1907	104	-----	-----	94	105	89	90	92	93	110	104	98
1908	96	-----	-----	97	93	95	92	93	96	112	100	97
1909	115	-----	-----	105	113	103	105	85	82	107	106	102
1910	120	-----	-----	114	105	116	99	95	97	117	104	107
1911	-----	-----	-----	109	106	89	97	104	103	103	106	102
1912	-----	-----	-----	118	119	138	109	118	116	129	108	119
1913	-----	-----	-----	92	104	98	88	111	91	109	86	97
1914	-----	-----	-----	103	115	108	101	105	104	101	106	105
1915	-----	-----	-----	96	130	122	126	103	82	106	81	106
1916	-----	-----	-----	123	106	123	133	91	105	109	-----	113
1917	-----	-----	-----	96	93	107	117	87	83	104	-----	98
1918	-----	-----	-----	98	98	121	116	109	105	110	-----	108
1919	-----	-----	-----	97	112	101	102	89	79	100	-----	97
1920	-----	-----	-----	110	-----	88	-----	-----	-----	-----	-----	99

TABLE 4.—*Percentages of rainfall in eastern United States*

Year	Charleston, S. C.	Washington, D. C.	Nashville, Tenn.	Savannah, Ga.	Philadelphia, Pa.	Pittsburgh, Pa.	Rochester, N. Y.	Albany, N. Y.	New York City, N. Y.	Penn Yan, N. Y.	Baltimore, Md.	St. Paul, Minn.	New Orleans, La.	St. Louis, Mo.	Lebanon, Pa.	Cincinnati, Ohio	Portsmouth, Ohio	Mean
1817	----	----	----	----	----	----	----	----	----	----	121	----	----	----	----	----	----	121
1818	----	----	----	----	----	----	----	----	----	----	81	----	----	----	----	----	----	81
1819	----	----	----	----	----	----	----	----	----	----	72	----	----	----	----	----	----	72
1820	----	----	----	----	115	----	----			----	106	----	----	----	----	----	----	110
1821	----	----	----	----	85	----	----			----	125	----	----	----	----	----	----	105
1922	----	----	----	----	72	----	----			----	73	----	----	----	----	----	----	72
1823	----	----	----	----	104	----	----			----	111	----	----	----	----	----	----	108
1824	----	71	----	----	116	----	----			----	105	----	----	----	----	----	----	97
1825	----	60	----	----	69	----	----			----	65	----	----	----	----	----	----	65
1826	----	46	----	----	82	----	----	86	131	----	76	----	----	----	----	----	----	84
1827	----	----	----	----	90	----	----	130	118	----	81	----	----	----	----	----	----	105
1828	----	58	----	----	91	----	----	98	115	----	82	----	----	----	----	----	----	89
1829	----	106	----	----	98	----	90	99	108	112	130	----	----	----	100	----	----	105
1830	----	----	----	----	105	----	102	109	102	104	97	----	----	----	98	----	59	97
1831	----	----	----	----	102	----	104	103	92	103	93	----	----	90	93	----	96	97
1832	95	----	----	----	93	----	94	116	93	106	85	----	----	----	84	----	111	99
1833	100	----	----	----	114	----	91	109	89	90	102	----	----	----	101	----	86	92
1834	141	----	----	----	80	----	51	85	80	77	73	----	----	----	79	----	83	83
1835	101	----	----	----	92	----	86	105	68	92	85	----	----	----	85	128	84	93
1836	84	116	----	----	100	----	84	116	86	90	132	----	92	----	90	141	99	103
1837	116	78	----	71	92	99	92	107	76	85	[illegible]	87	----	67	79	105	121	91
1838	121	----	----	----	106	----	76	116	80	105	117	100	----	70	81	97	94	96
1839	109	94	----	----	102	70	90	99	79	108	129	76	81	118	85	75	62	92
1840	95	----	124	94	111	79	88	115	84	102	93	83	78	103	65	116	103	96
1841	111	111	129	139	130	96	97	99	105	83	109	78	87	106	88	101	117	105
1842	87	----	112	127	114	112	100	120	98	105	87	95	77	80	90	101	103	100
1843	113	----	122	87	109	107	94	126	84	101	121	86	108	86	100	126	127	106
1844	75	----	88	97	94	90	78	91	94	69	81	109	86	114	73	106	84	89
1845	96	----	145	75	94	88	103	103	80	84	71	91	95	94	75	113	96	92
1846	91	102	----	113	103	132	111	104	85	106	116	94	118	113	107	132	110	108
1847	98	88	----	139	106	128	108	107	105	96	82	79	94	131	109	160	117	109
1848	89	57	----	113	82	95	96	126	77	78	86	83	94	162	75	124	100	96
1849	63	----	----	100	99	96	99	96	71	79	76	178	92	114	79	130	105	98
1850	49	----	----	110	128	104	115	135	105	109	111	92	90	126	145	134	139	113
1851	68	----	----	88	83	82	75	90	92	93	95	84	88	106	80	78	75	85
1852	103	99	----	109	107	114	105	84	83	----	128	54	77	116	99	133	96	100
1853	89	82	----	94	95	93	98	119	109	102	90	74	108	77	97	101	70	94
1854	78	77	----	86	94	74	88	89	103	68	147	96	93	101	85	125	76	93
1855	72	73	----	77	103	120	102	110	102	103	73	89	73	125	121	121	118	99
1856	101	83	----	90	79	74	86	102	83	75	57	82	118	105	71	63	----	85
1857	79	101	----	67	113	108	136	119	91	153	95	115	84	97	114	87	----	104
1858	99	97	----	106	93	100	108	89	87	92	115	99	106	171	98	121	----	105
1859	103	103	----	----	138	99	98	84	141	100	138	107	87	153	121	111	113	113
1860	91	92	----	----	103	99	89	84	73	89	93	125	69	74	109	86	82	91
1861	91	107	----	----	108	----	107	94	88	113	108	112	----	95	102	106	102	95
1862	107	93	----	----	105	81	116	99	110	109	88	123	----	110	87	94	97	102
1863	68	111	----	----	115	88	91	113	102	139	106	57	----	101	128	98	90	102
1864	118	83	----	----	108	----	122	73	93	110	57	53	----	94	87	82	87	84
1865	118	120	----	----	132	140	106	95	106	109	83	137	----	117	105	108	131	115
1866	75	118	----	----	106	----	107	89	90	93	68	100	----	104	89	122	109	98
1867	126	142	----	----	143	----	92	99	126	----	82	121	----	94	109	74	110	101
1868	126	115	----	----	120	----	118	109	135	----	81	110	----	113	84	111	110	111
1869	89	107	----	----	114	----	121	115	114	----	68	116	----	117	98	96	102	105
1870	99	89	----	----	103	----	119	145	100	119	56	110	85	73	92	77	99	112
1871	130	93	69	123	111	----	109	148	115	----	82	110	113	58	93	74	75	100
1872	117	75	84	127	113	88	109	102	108	----	88	107	106	76	----	85	76	98
1873	128	112	108	97	129	115	149	103	94	----	123	124	115	113	----	101	112	115
1874	129	85	122	114	108	109	107	99	94	103	84	128	106	94	----	92	93	104
1875	105	101	112	98	94	91	90	100	107	93	113	110	150	107	----	105	111	106
1876	161	117	98	129	111	102	108	100	111	117	116	85	118	120	----	129	100	114
1877	160	129	104	119	87	96	102	94	97	107	107	104	111	103	----	85	85	106
1878	159	147	102	105	81	107	146	128	110	143	125	82	116	102	----	102	73	114
1879	103	80	120	92	86	97	106	101	86	86	90	118	90	64	----	127	87	96
1880	96	95	141	100	79	89	125	85	88	83	104	107	122	86	----	134	119	103
1881	89	103	101	76	71	103	115	95	95	105	122	141	112	93	----	116	99	102
1882	117	114	132	94	107	107	75	88	110	81	105	83	88	107	----	128	137	105
1883	105	112	122	97	92	120	----	102	92	117	101	96	122	100	107	128	118	108
1884	124	122	113	101	92	97	94	101	131	92	114	94	105	101	110	96	103	105
1885	133	109	90	146	78	95	85	90	99	104	115	91	112	114	100	83	91	102
1886	74	142	94	85	87	103	111	89	110	109	130	82	96	110	96	77	110	101
1887	92	83	101	89	99	116	61	103	110	91	109	93	113	88	----	86	101	95
1888	102	111	105	94	103	110	83	116	125	104	109	93	146	103	103	86	117	106
1889	107	150	88	95	119	115	107	103	138	----	153	61	85	83	128	76	96	107
1890	98	102	125	95	80	140	130	117	123	----	117	84	74	94	113	117	140	109
1891	94	129	110	89	89	106	101	109	98	----	135	78	68	76	106	95	104	99
1892	110	103	105	85	81	90	105	91	92	----	112	117	100	104	98	78	107	99
1893	146	90	97	123	88	105	107	92	125	----	80	93	84	98	103	108	92	102
1894	117	76	88	105	91	78	105	92	104	----	95	93	95	68	115	63	88	92
1895	114	84	90	109	73	76	91	78	84	----	100	87	99	78	69	72	76	86
1896	98	76	84	88	75	123	110	73	90	----	96	125	87	91	97	85	97	93

TABLE 4.—*Percentage of rainfall in eastern United States*—Con.

Year	Charleston, S. C.	Washington, D. C.	Nashville, Tenn.	Savannah, Ga.	Philadelphia, Pa.	Pittsburgh, Pa.	Rochester, N. Y.	Albany, N. Y.	New York City, N. Y.	Penn Yan, N. Y.	Baltimore, Md.	St. Paul, Minn.	New Orleans, La.	St. Louis, Mo.	Lebanon, Pa.	Cincinnati, Ohio	Portsmouth, Ohio	Mean
1897	104	108	92	108	99	97	90	106	104	----	118	110	76	100	101	107	120	102
1898	96	92	105	120	115	99	113	101	107	109	91	91	86	122	114	96	117	104
1899	91	108	93	84	94	94	80	75	100	89	101	99	54	86	95	85	104	90
1900	79	101	102	90	96	71	114	80	98	105	79	123	99	74	84	68	84	91
1901	67	102	80	74	107	113	112	106	111	122	107	93	101	62	104	44	96	94
1902	77	114	92	94	116	89	89	97	111	101	125	114	73	96	120	92	90	99
1903	88	107	90	107	97	107	88	89	115	117	115	136	100	84	110	85	91	102
1904	78	100	78	81	93	94	104	82	98	----	90	122	77	84	103	73	71	89
1905	72	124	99	91	98	97	100	70	105	----	116	110	140	96	106	95	105	102
1906	90	129	103	79	121	87	89	85	99	----	116	119	73	88	109	100	108	100
1907	65	109	78	85	114	97	83	88	107	----	122	83	116	103	99	109	103	98
1908	65	94	71	95	89	84	83	65	98	88	88	114	88	85	96	67	97	86
1909	78	82	98	76	88	92	89	73	98	----	86	115	119	118	71	92	115	93
1910	82	96	90	93	93	88	106	74	85	----	87	36	90	93	97	85	104	87
1911	65	99	101	72	120	114	99	84	95	----	120	145	118	90	96	111	114	103
1912	105	108	112	123	110	106	89	84	91	----	112	76	143	111	90	95	104	104
1913	85	98	85	80	111	107	100	69	105	----	90	87	111	96	87	103	105	95
1914	91	94	84	87	92	93	90	78	79	----	91	89	96	89	93	80	96	89
1915	96	98	89	104	105	98	85	98	96	----	115	111	121	123	115	101	125	105
1916	88	94	91	76	76	97	108	88	78	----	90	88	104	104	91	94	110	92
1917	69	94	99	84	92	91	111	75	93	----	94	90	70	62	83	87	104	87
1918	65	90	85	86	88	90	88	79	79	----	93	108	107	90	82	103	97	89
1819	75	106	145	96	115	120	99	93	113	91	117	109	118	98	109	97	123	108
1920	96	99	121	115	108	93	83	106	114	----	120	89	114	78	107	99	98	102
1921	94	89	101	84	87	107	84	76	81	----	94	90	85	102	92	140	122	96
1922	104	115	127	116	74	88	99	89	101	125	106	90	100	81	79	95	98	99

TABLE 5.—*Percentages of annual rainfall in Pacific Coast States*

Year	The Dalles	Astoria	San Francisco	San Diego	Sacramento	Nevada City	Santa Barbara	Stockton	Mean
1850	------	------	75	82	102	------	------	------	86
1851	------	------	67	78	79	------	------	------	75
1852	------	------	113	123	141	------	------	------	127
1853	87	------	91	82	105	------	------	------	91
1854	75	77	97	121	104	------	------	------	95
1855	------	103	113	116	97	------	------	------	107
1856	------	77	96	101	75	------	------	------	87
1857	177	104	90	64	68	------	------	------	101
1858	262	82	101	88	88	------	------	------	124
1859	------	106	92	63	88	------	------	------	87
1860	128	92	91	95	103	------	------	------	102
1861	174	120	109	82	113	------	------	------	120
1862	98	79	166	120	144	------	------	------	121
1863	85	122	65	31	64	------	------	------	73
1864	------	98	93	79	101	88	------	------	92
1865	------	110	60	78	58	70	------	------	75
1866	------	129	156	128	139	151	------	------	141
1867	------	118	132	163	158	188	------	156	152
1868	------	75	130	116	102	118	86	107	105
1869	------	90	97	114	95	101	65	108	96
1870	------	93	70	45	54	92	63	44	66
1871	------	129	118	59	99	119	81	118	103
1872	------	96	97	52	100	113	57	108	89
1873	------	96	80	135	95	88	62	73	90
1874	------	105	97	113	94	102	67	104	97
1875	159	124	98	71	122	94	122	102	112
1876	93	110	101	75	95	98	91	83	93
1877	107	------	51	84	44	55	47	48	62
1878	75	------	143	144	123	100	167	121	125
1879	130	------	132	153	118	127	81	99	120
1880	82	------	129	106	167	129	161	125	128
1881	132	------	102	52	108	89	45	70	85
1882	93	------	80	101	95	85	68	74	85
1883	84	------	66	83	71	71	89	97	80
1884	111	64	167	286	183	156	212	172	169
1885	77	72	107	60	108	76	94	66	83
1886	82	93	86	160	95	80	76	82	94

TABLE 5.—*Percentages of annual rainfall in Pacific Coast States*—Con

Year	The Dalles	Astoria	San Francisco	San Diego	Sacramento	Nevada City	Santa Barbara	Stockton	Mean
1887	73	119	82	109	70	72	94	67	88
1888	70	89	99	120	97	71	147	89	96
1889	45	84	159	167	144	140	179	136	132
1890	74	76	110	83	110	114	85	85	92
1891	73	101	91	94	82	77	79	83	85
1892	72	91	95	95	124	114	106	102	100
1893	108	118	77	107	87	95	108	85	98
1894	108	115	105	45	119	112	55	153	102
1895	84	92	73	118	91	95	64	85	88
1896	101	122	117	91	132	127	103	112	113
1897	100	110	71	93	80	77	67	75	84
1898	46	89	40	48	53	44	40	49	51
1899	101	131	100	63	111	114	83	134	105
1900	82	110	66	60	94	80	58	100	81
1901	95	101	85	99	97	96	83	101	95
1902	105	112	82	119	94	90	98	86	98
1903	77	97	79	63	77	87	72	104	82
1904	96	115	106	69	110	125	114	115	106
1905	71	94	70	170	78	68	120	90	95
1906	90	106	113	155	161	151	153	182	139
1907	121	96	105	83	105	116	158	121	113
1908	49	74	71	89	59	58	93	68	70
1909	97	------	135	147	130	140	237	142	148
1910	83	113	53	60	41	59	60	58	66
1911	54	77	112	122	110	118	168	134	112
1912	101	111	56	110	58	69	77	69	81
1913	85	92	68	76	75	85	102	77	82
1914	78	99	86	113	84	88	163	112	103
1915	96	103	101	142	93	110	142	120	113
1916	94	120	125	120	96	105	104	129	123
1917	76	------	42	83	43	47	65	48	58
1918	72	------	90	124	84	75	157	104	101
1919	92	------	82	70	67	73	57	69	73
1920	68	105	78	80	77	102	76	90	84
1921	131	121	85	183	71	80	108	86	108
1922	------	------	111	96	96	120	123	136	114

TABLE 6.—*Annual rainfall of the Punjab*

[See Table 8, "A rainfall period equal to one-ninth the sun-spot period," D. A. University of Kansas Science Bulletin, Volume 13, No. 11]

Year	Amount	Per cent	Year	Amount	Per cent
1863	32.07	151	1891	19.34	91
1864	21.04	99	1892	26.17	123
1865	27.73	131	1893	32.59	153
1866	21.59	102	1894	34.23	161
1867	21.33	100	1895	20.34	96
1868	16.42	77	1896	14.47	68
1869	23.25	109	1897	18.72	88
1870	17.24	81	1898	19.81	93
1871	17.97	85	1899	8.89	42
1872	26.23	124	1900	26.36	124
1873	28.28	133	1901	15.17	71
1874	20.37	96	1902	14.01	66
1875	30.90	145	1903	17.39	82
1876	23.01	108	1904	15.87	75
1877	24.55	115	1905	14.87	70
1878	25.94	122	1906	20.84	98
1879	19.10	90	1907	15.52	73
1880	17.69	83	1908	25.16	118
1881	23.05	108	1909	21.64	102
1882	22.43	106	1910	17.68	83
1883	18.34	86	1911	15.44	73
1884	23.10	109	1912	15.37	72
1885	22.95	108	1913	17.64	83
1886	25.87	122	1914	25.28	119
1887	21.94	103	1915	11.70	55
1888	20.96	99	1916	19.62	92
1889	22.08	104	1917	31.67	144
1890	28.89	136	1918	10.00	47

Mean rainfall for period = 21.25 inches.

TABLE 7.—*Periodogram of northern Europe*

Period in years	Intensity	h	A(1748)	B(1748)	Phase, July, 1901
					°
8	43	0.58	−35	−39	----------
8⅛	129	1.75	−81	−41	----------
8¼	128	1.73	−90	+9	----------
8⅜	149	2.02	−95	+23	----------
8½	27	0.37	+7	+42	----------
8¾	60	0.81	−22	−66	----------
8⅞	98	1.33	−81	−37	----------
9	86	1.17	−78	−29	200
9⅛	62	0.84	−67	−22	112
9¼	77	1.04	−78	+11	39
9⅜	37	0.50	−55	−1	321
9½	26	0.35	−46	−1	217
9¾	62	0.84	−57	+54	26
10	170	2.30	−10	+130	202
10⅛	199	2.70	+33	+137	114
10¼	172	2.32	−100	+85	109
10½	20	0.27	−28	−35	64
10¾	24	0.33	−45	+29	----------
11	20	0.27	−7	+49	----------
11¼	17	0.23	−9	+44	----------
11½	3	0.04	+14	+13	----------
11¾	65	0.88	+83	−50	----------
11⅞	36	0.49	+29	−72	----------
12	59	0.80	+24	−89	----------
12⅛	70	0.95	−44	−90	----------
12¼	57	0.77	−53	−74	----------
12½	66	0.90	−97	+8	----------
12¾	66	0.90	−22	+103	----------
13	46	0.62	+24	+85	----------
13½	66	0.90	+104	+17	----------
14	51	0.69	+78	−62	----------
15	184	2.50	−64	−193	252
15¼	268	3.64	−175	−172	215
15½	297	4.03	−250	−76	150
15⅝	324	4.40	−272	−2	96
15¾	430	5.83	−303	+135	55
16	255	3.46	−171	+195	329
17	41	0.56	+78	+77	----------
18	23	0.31	+83	+23	----------
19	29	0.39	−40	−100	----------
20	23	0.31	−70	+65	----------
21	19	0.26	+70	−66	----------
22	84	1.14	−141	−141	----------
23	142	1.92	−256	+97	----------
23¼	149	2.02	−246	+136	----------
23½	129	1.75	−173	+202	----------
24	146	1.98	−82	+278	----------
25	116	1.57	+126	+238	----------
26	72	0.98	+208	+74	----------
27	73	0.99	+176	−149	----------
28	32	0.43	+29	−155	----------
29	23	0.31	−100	−96	----------
30	7	0.09	−79	+19	----------
31	10	0.14	−88	+71	----------
32	11	0.15	+107	−17	----------
34	50	0.68	−53	−234	----------
36	76	1.03	−309	−50	----------
37	115	1.56	−370	+145	----------
37½	102	1.38	−308	+210	----------
38	112	1.52	−252	+313	----------
39	96	1.30	−120	+363	----------
40	93	1.26	+1	+367	----------
44	23	0.31	+198	+79	----------
48	19	0.26	+16	+207	----------

Mean intensity=74.

TABLE 8.—*Periodogram of eastern United States*

Period in years	Intensity	h	A(1820)	B(1820)	Phase, July, 1901
					°
8	36	0.94	+14	−46	----------
8⅓	11	0.29	0	+27	----------
8⅔	22	0.57	+9	+41	----------
9	117	3.05	+49	+84	60
9⅓	125	3.26	+92	+41	265
9⅔	174	4.53	+116	−63	104
9¾	134	3.49	+104	−51	82
10	119	3.10	+103	−36	17
10¼	160	4.17	+113	−57	297
10⅓	113	2.94	+61	−81	249
10½	130	3.39	+55	−100	217
11	1	0.03	−4	+10	----------
11½	39	1.02	+66	−20	----------
12	40	1.04	+48	−59	----------
13	28	0.73	+63	−27	----------
14	94	2.45	+68	−117	224
14½	96	2.50	+25	−135	130
15	83	2.16	−55	−125	54
15½	70	1.82	−95	−82	301
16	11	0.29	−53	−7	----------
17	13	0.34	+54	−43	----------
18	29	0.76	−6	−96	----------
19	17	0.44	−61	−48	----------
20	10	0.26	−35	+52	----------
22	12	0.31	+69	−31	----------
24	10	0.26	+70	−29	----------
26	36	0.94	+137	−74	----------

TABLE 9.—*Periodogram of California and Oregon*

Period in years	Intensity	h	A(1850)	B(1850)	Phase, July, 1901
					°
8	674	2.252	+129	+163	----------
8⅓	93	0.310	+77	+2	----------
8⅔	4	0.010	+17	−4	----------
9	442	1.471	+173	+76	264
9⅓	1,342	4.475	+307	+121	148
9½	634	2.112	+152	−168	82
9⅔	734	2.453	−97	−253	346
10	360	1.201	−150	−116	254
10½	26	0.090	+42	−26	----------
11	96	0.320	−34	−102	----------
11½	387	1.291	−135	−167	----------
12	404	1.351	−241	+10	----------
12¼	362	1.211	−124	+35	----------
12½	609	2.032	−278	+102	----------
13	434	1.451	−109	+248	----------
14	307	1.021	+184	+167	----------
15	308	1.031	+186	−186	99
15⅓	146	0.490	+85	−160	----------
15½	193	0.640	+54	−201	----------
15⅔	294	0.981	−28	−273	355
16	122	0.410	−78	−158	----------
17	130	0.430	−151	+122	----------
18	98	0.330	+139	+111	----------

TABLE 10.—*Periodogram of the Punjab*

Period in years	Intensity	h	A(1863)	B(1863)	Phase, July, 1901
					°
8	633	0.39	−77	−186	----------
8⅓	228	0.14	−110	−50	----------
8⅔	857	0.53	−59	+257	----------
9	1,295	0.80	+27	+323	----------
9½	737	0.45	+33	+242	----------
10	1,607	0.99	+298	+268	330
10¼	2,250	1.39	+351	+319	60
10½	2,138	1.32	+409	+216	251
11	1,530	0.94	+428	−45	----------
11½	518	0.32	+239	−75	----------
12	185	0.11	+149	−65	----------
13	667	0.41	+225	+249	----------
14	2,392	1.80	+672	+134	268
15	3,218	1.99	+769	−365	166
15⅓	3,171	1.96	+725	−435	142
15⅔	4,478	2.95	+544	−923	94
16	3,840	2.37	+499	−857	76
17	2,800	1.73	−121	−892	----------
18	1,340	0.83	−310	−571	----------

TABLE 11.—*Length of record, normals, etc., for the stations used in Tables 3, 4, and 5*

Stations	Number of years	Normal	Remarks
TABLE 3		*Inches*	
Lund	160	17.18	1861 to 1910 means are from Swedish towns.
		20.58	Compiled by author.
Abo	131	23.79	Published mean. Beginning with 1803
		22.39	Warsaw is substituted.
Montdidier	107	--------	
Copenhagen	100	22.70	Compiled by author.[1]
Denmark (all stations)	60	26.42	Manuscript from Prof. Carl Ryder; published by author.[2]
Chilgrove	86	34.31	British Rainfall, 1919.
Utrecht	72	28.52	
London	60	25.59	Rainfall British Isles, Salter, p. 215.
Haverfordwest	60	48.03	Do.
Glengyle	60	91.84	Do.
Belfast	60	34.57	Do.
Four stations in Norway	49	49.72	Averaged from data given on pp. 64-65. Nedboriagttagelser i Norge (1918).
TABLE 4			
Charleston, S. C	91	48.59	New Orleans from Annual Summary of that station; all others from Climatological Data by Sections.
Washington, D. C	83	40.80	
Nashville, Tenn	58	47.89	
Savannah, Ga	72	50.06	
Philadelphia, Pa	103	42.90	
Pittsburgh, Pa	78	36.17	
Rochester, N. Y	93	33.34	
Albany, N. Y	97	38.39	
New York, N. Y	97	42.47	
Penn Yan, N. Y	62	28.99	
Baltimore, Md	106	40.20	
St. Paul, Minn	86	27.80	
New Orleans, La	76	56.30	
St. Louis, Mo	87	40.10	
Lebanon, Pa	82	44.45	
Cincinnati, Ohio	88	40.63	
Portsmouth, Ohio	97	42.47	
TABLE 5			
The Dalles, Oreg	55	16.50	Climatological Data of United States by Sections and manuscript data from Mr. E. A. Beals and Mr. E. L. Wells.
Astoria, Oreg	61	77.24	
San Francisco, Calif	73	23.25	
San Diego, Calif	73	9.63	
Sacramento, Calif	73	19.10	
Nevada City, Calif	59	54.61	
Santa Barbara, Calif	55	18.23	
Stockton, Calif	56	14.57	

[1] Kansas Univ. Sci. Bull. 12: 76, July, 1912.
[2] Kansas Univ. Sci. Bull. 12: 54, July, 1912.